R. W. Mohrhauser

29 OCTOBER 1962

BELLCOMM, INC.

QUARTERLY PROGRESS REPORT

JULY AUGUST SEPTEMBER

1962

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OFFICE OF MANNED SPACE FLIGHT, BY
BELLCOMM, INC., WASHINGTON, D.C.

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Report No. 62-100-1
Contract NAS$_{w}$-417
29 October 1962

NASA APOLLO PROGRESS REPORT

BELLCOMM, INC.

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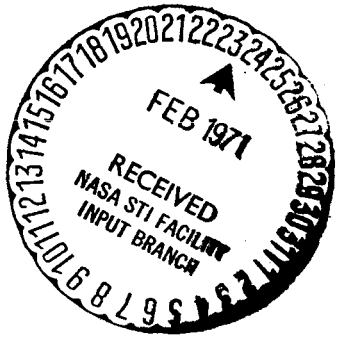

J A Hornbeck
President

BELLCOMM, INC.

Washington, D.. C..

QUARTERLY PROGRESS REPORT

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ABSTRACT

The activities of Bellcomm, Inc. during the quarter ending September 30, 1962 are summarized.

BELLCOMM, INC.

QUARTERLY PROGRESS REPORT

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Table of Contents

INTRODUCTION

A letter progress report covering the formation of Bellcomm, Inc., early administrative and recruiting activities, and initial technical effort was forwarded to the NASA Office of Manned Space Flight on July 27, 1962. Although recruiting of technical personnel and problems of initial organization continued to require a substantial allocation of Bellcomm effort, technical activities during July, August and September 1962 reached a level which justifies a more detailed report. This technical progress report covers these activities and establishes the framework within which future technical effort will be documented.

GENERAL SYSTEMS ENGINEERING ACTIVITIES

Initial technical activity at Bellcomm has been centered on the orientation of technical personnel in the APOLLO mission and equipment, and in the technical disciplines needed for space exploration. This entailed individual study, group discussions and seminars, and attendance at many meetings and presentations some of which are noted in Appendix A. During this process areas were noted where information or understanding required for anticipated systems studies was incomplete. In a number of these areas effort was initiated to review existing knowledge and to identify and explore factors entering into APOLLO system tradeoffs. Examples of such effort have been included in the following summaries of representative Bellcomm general systems engineering activities.

Mission Planning and Mission Assurance

1. A preliminary study of the entire APOLLO trajectory was initiated. Effort was centered on general studies of orbital mechanics applicable to the mission and on investigation of important variables and constraints affecting the trajectory, including:
   (a) The manner in which launch windows are affected by launch azimuth, declination of the moon, inclination of the moon's orbit to the earth's equatorial plane, permissible plane changes, and time of flight to the moon.
   (b) The velocity increments required throughout nominal APOLLO trajectories and the penalties associated with plane changes.
   (c) The velocity increment required for midcourse correction of errors and its dependence on the point of application.
   (d) The effect upon lunar parking orbits of the time of flight to the moon and the dihedral angle between the earth-moon flight plane and the moon's orbital plane.

(e) The interrelation between the point of re-entry, the declination of the moon at time of departure from the moon, and the dihedral angle between the moon-earth flight plane and the earth's equatorial plane.

The results of these investigations will be used in continuing trajectory studies.

2. Insight into guidance and navigation system tolerance requirements was developed by calculation of approximate sensitivities for selected earth-moon and lunar descent trajectories. Approximate midcourse sensitivities for an assumed APOLLO navigation scheme were determined using planar flight trajectories.

3. An investigation of various midcourse guidance systems has been initiated with the objective of relating guidance equipment accuracy and complexity to guidance errors and resulting propellant requirements. Continuing effort will be applied to this study.

4. Reliability concepts and procedures used on large programs were reviewed with several development and engineering organizations.

5. Types of environmental data required for effective and safe conduct of the APOLLO mission were defined and compared with the anticipated results of the current Unmanned Program. Disparities in adequacy or timeliness of data are being examined to establish needs for improved support by the Unmanned Program and other projects. A more detailed study of environmental hazards to the APOLLO mission is being pursued under Task Order No. 4.

6. Approximately twenty-five Bellcomm staff members participated in a seminar on celestial mechanics led by specialists in this field from Bell Telephone Laboratories.

Mission Operations

A functional description of the APOLLO mission was generated on a chronological basis. This functional description is being used in connection with communications and tracking study effort under Task Order No. 6.

Vehicle and Spacecraft Systems

1. A study to identify the basic launch vehicle parameters which can be used to control vehicle performance and design margins continued during this report period. Results to date are being reflected in applicable portions of the APOLLO System Specification (Task Order No. 1).

2. An investigation is in process to determine module weights and associated propulsion margins for a spacecraft capable of being launched on the Saturn C-5 with a trajectory utilizing: (a) two stages to earth orbit, or (b) two stages plus a partial burn of the third stage under conditions where one second stage engine is out.

3. A survey was conducted to identify guidance and navigation concepts currently contemplated for APOLLO including proposed techniques for precision landing on the lunar surface. The results provided necessary background information for anticipated spacecraft and mission planning investigations.

Launch Operations and Checkout

A preliminary study was initiated to determine the checkout operations required for successful conduct of the APOLLO mission and to develop a conceptual checkout plan for performing these operations. Consideration was given to:

1. Requirements for checkout operations at various phases of the APOLLO mission.
2. The checkout objectives at each phase of the mission.
3. The basic processes used to meet these checkout objectives.
4. Applicability of digital computer techniques to solutions of APOLLO checkout problems.

Negotiations are in process to expand the definition of Task Order No. 2 to cover intensified efforts in the development of a checkout plan for APOLLO.

Communications and Tracking

Portions of the ground support function which pertain to communications and tracking were identified and an outline of studies required to fully define requirements for the APOLLO Communications and Tracking System was developed. Study effort was organized and initiated in accordance with the outline. Effective August 28, 1962, Task Order No. 6 was authorized to cover continuing effort in this area.

Consulting Support

On several occasions staff members assisted the Office of Systems in resolving questions pertaining to radiation fluxes, meteorite hazards and mode comparisons.

SPECIFIC CONTRACT TASKS

During this report period a procedure for defining specific studies to be conducted by Bellcomm under Contract NASw-417 was established and seven (7) task orders were initiated. The title and estimated completion date for each task are enumerated below. Separate technical reports pertaining to individual task orders will be prepared and distributed in accordance with task order requirements.

TASK ORDER NO.	TITLE	ESTIMATED COMPLETION DATE
1	Assist NASA in preparation of a system specification for the manned space flight program.	November 30, 1962
2	Conduct a preliminary study of check-out and launch from lunar surface.	January 31, 1963
3	Estimate the computing needs of the Office of Systems and Bellcomm, Inc.	October 31, 1962
4	Carry out a study leading to the classification and characterization of the natural environmental hazards to APOLLO mission success.	January 31, 1963
5	Assist NASA in developing a mission assurance program for APOLLO.	November 30, 1962
6	Formulate the systems requirements and develop a broad implementation plan for the Communications and Tracking System.	December 15, 1962 (Phase I)
7	Review the Lunar Logistic System Program and its relationship to the APOLLO program.	November 1, 1962

ADMINISTRATIVE ITEMS OF INTEREST

Significant administrative events of the past quarter which have contributed to the growth of Bellcomm technical capability or to the fulfillment of contract requirements are noted below.

Personnel

As of October 1, 1962, the Bellcomm staff consisted of 61 technical employees and 47 administrative employees, totaling 108. In recruiting this staff, offers of employment were made to 141 individuals selected from the more than 500 candidates considered.

Approximately 90 per cent of the technical employees on roll were recruited from Bell System Companies (principally Bell Telephone Laboratories). Over two-thirds of the administrative employees were hired locally without assistance from Bell System Companies.

Office Facilities

During the report period, Bellcomm's temporary location at 1737 L Street, N. W., Washington, D. C. was augmented by additional facilities at 1730 K Street, N. W., 2117 M Street, N. W. and 1000 Connecticut Avenue, N. W.

Bellcomm has leased permanent quarters in a building now under construction at 1100 17th Street, N. W., Washington, D. C. These quarters will be occupied early in 1963.

Technical Library

In order to serve the needs of the technical staff, a technical library has been established at Bellcomm under the supervision of a professionally trained librarian. This library is working in cooperation with the NASA Office of Scientific and Technical Information.

Contract and Financial

Negotiations with the NASA Contracting Officer for a definitive contract covering Bellcomm operations continued throughout the reporting period.

Content and format of financial reports prepared in connection with the contract were developed as the result of dicsussions with NASA. Reports covering operations through August were delivered to NASA on September 18, 1962.

Cost estimates for the first reporting period under the proposed definitive contract were furnished to NASA on August 15, 1962.

The firm of Lybrand, Ross Bros. and Montgomery was selected to perform the annual Bellcomm, Inc. audit.

APPENDIX A

TECHNICAL REPORTS

During this report period a document entitled, "Project Apollo Preliminary System Specification", dated 24 August, 1962 (CONFIDENTIAL) was released. Two hundred (200) copies were forwarded to the Office of Manned Space Flight, Code MEA, on September 7, 1962.

APPENDIX B

MEETINGS AND FIELD TRIPS

Record of Bellcomm Participation

Date: July 5, 1962
Place: Executive Office Building
Attendees: S. Darlington, J. A. Hornbeck, T. H. Thompson
Meeting: President's Scientific Advisory Committee Presentation

Date: July 10, 1962
Place: Bell Telephone Laboratories, Inc., Holmdel, N. J.
Attendees: C. A. Lovell, I. D. Nehama, C. C. Willhite
Meeting: Electronic Switching Techniques
A presentation by BTL covering techniques developed for Electronic Switching Systems which could have application to APOLLO checkout equipment.

Date: July 10, 1962
Place: NASA Headquarters
Attendees: B. Kaskey, R. A. Kaenel
Meeting: Cryogenic Propellants
Lewis Research Center personnel presented the results of a recent study which reviewed and evaluated all propellants of current interest.

Date: July 17-19, 1962
Place: Cleveland, Ohio
Attendees: T. M. Burford, D. B. James, T. H. Thompson
Meeting: American Rocket Society Meeting
Papers were presented covering:

1. The nature and composition of the moon and cislunar space environment.
2. Design, trajectory and abort considerations for several manned lunar mission modes.
3. Descriptions of funded programs, i.e. Ranger Apollo, Surveyor, Saturn.

Date: July 18, 1962
Place: NASA Headquarters
Attendees: W. S. Boyle, G. B. Troussoff
Meeting: NASA Paraglider Development Program
The Paraglider concept was discussed with representatives of OMSF and MSC. Specifications and development mileposts for the Gemini Paraglider program were presented.

Date: July 18, 1962
Place: Marshall Space Flight Center
Attendees: S. Darlington, R. A. Kaenel, B. Kaskey, C. R. Moster
Meeting: C-5 Vehicle
Stage sizes and weights for the C-5 vehicle were reviewed by representatives of MSFC. The C-5 Guidance and control instrumentation was discussed.

Date: July 24 and 25, 1962
Place: Ames Research Center
Attendees: S. Darlington, J. P. Downs, R. A. Kaenel
Meeting: Intercenter Conference on Navigation and Guidance

Date: July 24 and 25, 1962
Place: Manned Spacecraft Center
Attendee: R. W. Sears
Meeting: Quarterly Review of Philco's Work on IMCC

Date: July 27, 1962
Place: NASA Headquarters
Attendees: W. D. Lewis, T. H. Thompson
Meeting: APOLLO Trajectory

Date: July 31 — August 1, 1962
Place: Langley Research Center
Attendee: B. T. Howard
Meeting: Symposium on Manned Space Stations
The symposium was a report to NASA centers on some preliminary work carried out at LRC and NAA.

Date: August 2, 1962
Place: NASA Headquarters
Attendee: J. P. Downs
Meeting: Briefing for G. E. Fact-Finding Group

Date: August 3, 1962
Place: NASA Headquarters
Attendees: B. T. Howard, D. B. James
Meeting: Briefing by RCA on Ranger Orbiter

Date: August 3, 1962
Place: NASA Headquarters
Attendee: B. T. Howard
Meeting: Meteoroids
The meeting was held with representatives of OART and OSS to discuss the flux of primary meteoroids near and at the lunar surface, the flux of secondary meteoroids near and at the lunar surface, and the hypervelocity impact phenomena.

Date: August 9, 1962
Place: Manned Spacecraft Center
Attendees: J. O. Cappellari, L. Rongved, T. H. Thompson
Meeting: APOLLO Trajectories
Representatives of MSC described their activities in the field of APOLLO trajectories.

Date: August 13 - 17, 1962
Place: Virginia Polytechnic Institute
Attendee: G. T. Orrok
Meeting: Conference on Lunar Exploration

Date: August 14, 1962
Place: NASA Headquarters
Attendees: J. A. Hornbeck, C. A. Lovell, I. D. Nehama, J. M. West, C. C. Willhite
Meeting: APOLLO Checkout
Bellcomm's responsibility in the checkout area was discussed with representatives of OMSF.

Date: August 15, 1962
Place: Goddard Space Flight Center
Attendees: J. P. Downs, R. E. Driscoll, H. A. Watson
Meeting: Communications and Tracking
Existing and currently funded equipment for Mercury and Gemini was described. A proposed range and range rate tracking system for near earth and deep space tracking was explained.

Date: August 15 - 16, 1962
Place: McDonnell Aircraft Co., St. Louis, Mo.
Attendee: B. Kaskey
Meeting: Gemini Mock-Up Review
A Mock-up Review of the Project Gemini Spacecraft was conducted at McDonnell Aircraft.

Date: August 21, 1962
Place: Rice Hotel, Houston, Texas
Attendees: B. Kaskey, R. W. Sears, W. Strack, M. P. Wilson
Meeting: Results of the Second United States Manned Orbital Space Flight on May 24, 1962

Date: August 21-22, 1962
Place: Cape Canaveral
Attendees: C. A. Lovell, I. D. Nehama
Meeting: APOLLO Checkout and Launch

Date: August 22, 1962
Place: Manned Spacecraft Center
Attendee: J. P. Downs
Meeting: Communications and Tracking Requirements

Date: August 23, 1962
Place: NASA Headquarters
Attendees: J. L. Glaser, T. H. Thompson, J. M. West
Meeting: APOLLO System Specification

Date: August 23 - 24, 1962
Place: Marshall Space Flight Center
Attendees: C. A. Lovell, I. D. Nehama
Meeting: APOLLO Checkout

Date: August 28, 1962
Place: JPL, Pasadena, California
Attendees: T. M. Burford, J. O. Cappellari, R. A. Kaenel, L. Rongved, T. H. Thompson
Meeting: Lunar Trajectories and Guidance
JPL's work on lunar trajectory calculations, computer programs and guidance studies was discussed.

Date: August 29, 1962
Place: NASA Headquarters
Attendee: D. B. James
Meeting: Briefing on Effects of July 9, 1962, High Altitude Atomic Test

Date: August 29-30, 1962
Place: Manned Spacecraft Center
Attendee: J. P. Downs
Meeting: Philco's Monthly Progress Report on IMCC

Date: August 30, 1962
Place: Cape Canaveral
Attendee: C. A. Lovell
Meeting: Organizational Meeting of the Checkout Design Review Board

Date: August 31, 1962
Place: NASA Headquarters
Attendees: W. S. Boyle, D. B. James
Meeting: Lunar Logistics
A briefing given by Melpar, Inc. on a lunar logistic organization.

Date: September 5, 6, 7, 1962
Place: Battelle Memorial Institute, Columbus, Ohio
Attendees: I. D. Nehama, A. H. Scheinman
Meeting: Automatic Checkout Techniques

Date: September 6, 1962
Place: NASA Headquarters
Attendees: J. L. Glaser, J. J. Hibbert, J. A. Hornbeck, C. R. Moster, W. Strack, T. H. Thompson, J. M. West
Meeting: APOLLO System Specification

Date: September 7, 1962
Place: NASA Headquarters
Attendees: J. L. Glaser, J. J. Hibbert, J. A. Hornbeck, W. Strack, T. H. Thompson, J. M. West
Meeting: Review of "Preliminary Operational and Design Ground Rules for the APOLLO System" prepared by the System Support Group

Date: September 7, 1962
Place: NASA Headquarters
Attendee: G. T. Orrok
Meeting: Lunar Imagery
Comments were presented on the mapping and surface texture portions of the OMSF document, "Requirements for Data for Project APOLLO".

Date: September 7, 1962
Place: Manned Spacecraft Center
Attendee: J. P. Downs
Meeting: APOLLO PIRD Committee Meeting

Date: September 10, 1962
Place: NASA Headquarters
Attendees: J. L. Glaser, J. J. Hibbert, W. Strack, T. H. Thompson, J. M. West
Meeting: APOLLO System Specification
First meeting of the steering panel for the APOLLO System Specification.

Date: September 10-11, 1962
Place: Goddard Space Flight Center
Attendee: H. J. Schulte
Meeting: Symposium on Artificial Radiation Belts
Trapped radiation resulting from the Project Starfish high altitude nuclear explosion on July 8, 1962, was discussed.

Date: September 11, 1962
Place: Morehead Planetarium, N. C.
Attendee: H. N. Dorris
Meeting: Navigational Studies
Mr. A. F. Jenzano, director of the Morehead Planetarium, discussed use of the planetarium for advanced navigational studies.

Date: September 11, 1962
Place: General Electric Company, Syracuse, N. Y.
Attendees: T. J. Celi, R. L. Wagner
Meeting: Status Review of the G. E. APOLLO Program

Date: September 17, 18, 1962
Place: G. E. Defense Systems Department, Syracuse, N. Y.
Attendees: W. Strack, R. L. Wagner
Meeting: APOLLO System Description Review

Date: September 18, 1962
Place: NASA Headquarters
Attendee: T. L. Powers
Meeting: Surveyor Payload Briefing
Scientific experiments proposed for light weight Surveyor missions were outlined by OSS.

Date: September 19, 1962
Place: NASA Headquarters
Attendees: C. J. Byrne, J. O. Cappellari
Meeting: Selenodesy Working Group — Meeting #2

Date: September 19, 1962
Place: Grumman Aircraft Engineering Corp.
Attendee: H. W. Radin
Meeting: Payload Performance Study for LLS
Grumman's preliminary plan for the LLS payload performance study was presented and discussed.

Date: September 20, 1962
Place: Marshall Space Flight Center
Attendees: C. J. Byrne, T. L. Powers
Meeting: Presentation on LLS

Date: September 20, 1962
Place: NASA Headquarters
Attendees: T. J. Celi, R. L. Wagner
Meeting: Mission Assurance
A briefing by General Electric on the procedures used in mathematically describing the reliability model for the Mercury capsule.

Date: September 21, 1962
Place: Manned Spacecraft Center
Attendees: C. A. Lovell, I. D. Nehama, C. C. Willhite
Meeting: Checkout Philosophy

Date: September 21, 1962
Place: NASA Headquarters
Attendee: R. W. Sears
Meeting: Conference on Human Factors
A discussion of ground rules and boundary conditions for the North American and Martin reliability studies of astronaut performance.

Date: September 21, 22, 23, 24, 1962
Place: Cape Canaveral
Attendees: G. W. Craft, C. M. Klingman, V. Muller, A. H. Scheinman
Meeting: Inspection Tour
The tour covered Saturn Launch Facilities, Mercury demonstrations and simulations, and a review of current plans for Complex 39.

Date: September 26, 1962
Place: Jet Propulsion Laboratory
Attendee: H. Kraus
Meeting: Existing and Planned Communications Tracking Facilities of JPL

Date: September 26 - 27, 1962
Place: Jet Propulsion Laboratory
Attendee: D. B. James
Meeting: Lunar Orbiter
Discussions and presentations on the Ranger and Able Lunar Orbiter proposals.

Date: September 28, 1962
Place: Goddard Space Flight Center
Attendees: L. G. Miller, R. W. Sears
Meeting: Mercury MA-8 Mission Simulation
A preflight simulation of the Mercury MA-8 Mission at the GSFC Computation Center.

Date: September 28, 1962
Place: Cape Canaveral
Attendees: G. W. Craft, J. P. Downs, B. T. Howard, C. M. Klingman
Meeting: Mercury MA-8 Mission Simulation
A preflight simulation of the MA-8 Mercury Mission on blockhouse equipment at Cape Canaveral.

Date: September 28, 1962
Place: Manned Spacecraft Center
Attendees: S. Darlington, R. A. Kaenel, C. R. Moster, T. H. Thompson
Meeting: Spacecraft Guidance

The history and background leading to current designs for spacecraft guidance systems were reviewed by MSC personnel.